Technical Description

Urbanistic and architectural concept

The Városligeti Fasor axis projects the city's urban configuration into the centre of the park. The layout of the quadratic site within the park adopts this configuration. The square generates a decumanus, oriented towards the Széchenyi Bath. This rational, urban configuration is superimposed with the organic, floral order and design vocabulary of the park, which is arranged in the English style as an idealised landscape, surrounding the perfectly solitary, quadratic building on all sides. The interlacing of the two contrasting arrangements enhances the aesthetic presence of both and leads, in a play of antitheses, to a higher, virtually aesthetic unity between rationality and nature.

A system of garden walls, which are archaeological in their appearance, is generated by the new composition and give the landscape a new order, while incorporating the existing trees to the greatest extent possible. These walls modulate the site, opening up the terrain towards the museum in its centre and thus allowing for ground-floor access to two of the building's three main levels.

The three main floors with a clear inside height of 6.5 metres are freely spanned by 2 metre high, quadratic grids, which rest on four external building volumes and one central volume. The flowing universal space in between is held by the four external volumes. Between the volumes the space opens up through protective cantilevers into the depth of the park.
The fluid space is devoted to exhibition and foyer areas, while the remaining programme, the required vertical circulation and the technical shafts are accommodated in the four external building volumes. The vast floor heights allows for a mezzanine floor to be established in the outer volumes.

The central volume, housing the sculpture courtyard, cuts vertically through all three floors and has zenithal lighting. Daylight seeps into the exhibition galleries through its double layer cladding crafted from translucent marble. As a shimmering volume in the centre of the floor plan, the courtyard volume organises the route, comparable to the Pantheon in Schinkel's Altes Museum, without being directly accessible in the upper floors. In direct proximity to the central sculpture courtyard, the main staircase, linking the three exhibition floors, is likewise lit from above.

A coffered ceiling allows the column-free space to be divided flexibly through room-height partition walls. The ventilation is completely incorporated into the ceiling, making it possible to integrate entirely closed rooms into the flowing space. The light ceiling can be individually controlled within the ceiling grid. Behind the acoustically effective membrane, LED lights enable the intensity and tone of the light to be altered independently. Highlighting can be added individually.

The exhibition spaces have a clear structure. The permanent exhibition of the New National Gallery is situated on the uppermost floor. The floor below houses the temporary exhibition, the main foyer and the main entrance from the south in the Városligeti Fasor axis. The Museum Ludwig is situated in the lower storey with the possibility of a separate entrance from the east. This organisation provides the possibility of a continuous tour route through all exhibition areas as well as separate access to the different exhibition areas. The ground level access of both lower floors furthermore facilitates separate opening times for the shops, cafés and conference areas.

Art-handling, back-of-house and parking are located in the basement storeys, while the GAIA lab is housed in one of the outer volumes on the uppermost floor. As is the case for the sculpture garden, the lab will have zenithal daylight from above.

The reduced palette of materials is complemented by the façade of the building volumes, made out of slabs of translucent white recycled glass ceramic (Structuran) and the travertine of the garden walls. Vertically a sequence of attractive, mineral materials addresses the theme of light, ranging from opaque travertine to the opal materials of marble and Structuran to transparent glass. In contrast the horizontal is defined by the steel structure and is more passive in terms of material.

The architectural language of the New National Gallery and Ludwig Museum embodies, in a modern way, key models of museum architecture, generating an ideal architecture which will remain relevant in the long-term. The architecture avoids fashionable trends, aiming to provide an appropriate home for the canonical collection of a national gallery. It provides space for art from the 19th century to the contemporary including the future without replacing the art itself through architecture. In a calm, protected yet accessible atmosphere, the building allows for an ideal encounter between visitor and art. Its magnificent location in Budapest's City Park results in a dense, aesthetic experience of art, nature and architecture, enabling the visitor to see the city and its art with new eyes.

1 Building Services and Sustainability Strategies

The building services strategy for the new Liget Museum has been developed within the framework of the following design requirements:
— Liget Budapest, New National Gallery and Ludwig Museum Competition Programme (Oct. 2014)
— Aspiration to achieve BREEAM Excellent.
— International Standards for Best Practice

1.1 Design Vision
The MEP systems will be developed with the following aims:
— Environmental control systems providing world class art conservation requirements
— Low energy systems
— Robust systems design that can be delivered and easily maintained using readily available local technologies with internationally benchmarked capability for conservation.
— Resilient systems with back up for component failure
— Flexible distribution systems that can respond to flexible architectural layouts
— Modular systems that facilitate gallery rehangs and diverse occupancy trends
— Excellent air quality and low noise environments
— Low energy passive systems in all non critical spaces
— Optimum daylighting in all non-critical spaces.

1.2 Sustainability
The engineering concepts will strive to minimise carbon emissions and the usage of natural resources without compromising the comfort and quality of the internal space for its users. The strategy follows an Energy Hierarchy:
1 Passive measures to reduce the building's primary energy demand
2 Active measures to maximise the efficiency of energy supply and services distribution systems
3 Consideration of low and zero carbon energy sources where appropriate and financially viable

1.2.1 Passive Measures
The building envelope will have a high performance, with low U-values and excellent air tightness to minimise excessive heat losses through the building envelope. Deployable shading will be optimized to reduce unwanted solar gains in summer, while letting the gains into the building in winter to provide passive heating. The amount of glazing on the office façades have been optimized at ca. 40% to balance maximum daylight penetration against minimum heat losses.
The relative heights and depths of perimeter office spaces have been set to maximize opportunities for natural ventilation. Where the depth of a perimeter space is too deep to be naturally ventilated, dedicated air shafts to the roof have been incorporated to induce a stack effect and help pull the fresh air all the way through the space. To maintain the façade's air-tightness, and reduce building costs and complexity, the natural ventilation openings will be integrated into the building's opaque elements. This will also allow them to include acoustic protection in the air paths, preventing internal disruption from noise outside.

1.2.2 Active Measures
Ventilation and cooling to office and perimeter auxiliary spaces will be provided by a mixed-mode system – natural ventilation when external conditions are favourable, and a variable air-volume (VAV) system during peak periods. The building management system will alert occupants as to when the natural ventilation system can be used, and interlocks between the ventilation openings in the façade and VAV boxes will ensure the mechanical system serving a particular zone is switched off when that zone is being naturally ventilated.
The ventilation systems to the galleries will be designed to allow for 100% fresh air free cooling when external conditions are appropriate.
The air-handling units will use carbon dioxide sensors with recirculation sections to ensure that only the minimum amount of fresh air required will need to be conditioned, and high efficiency thermal wheels to further decrease the amount of energy needed to do so. The air-handling plant and associated ductwork will be generously sized to decrease air system pressure losses, reducing fan energies. Circulation pumps will be variable speed to reduce pump energy during part load periods.
All electrical lighting will be by low energy LED fittings controlled by time and occupancy sensors, to ensure electricity for lighting is not being used when not needed. In addition, perimeter lighting will also be controlled by daylight sensors and be dimmable so that they do not consume energy when a space is being lit naturally.
A full and sophisticated building management system will be used to ensure all services are provided only where and when they are required, and optimised to meet minimum demand only, further reducing unnecessary energy consumption.

1.2.3 Low and Zero Carbon Energy Sources
Heating and cooling to the building will be provided primarily by a ground source heat pump system using energy piles. The opportunity to incorporate photovoltaic panels on the large roof expanse will be investigated during the design stage to determine its economic viability. However, if installed, the panels would help reduce the building's electricity demand from the city's grid.

1.3 Building Services
1.3.1 Heating and Cooling
Heating and cooling to the building will be provided primarily by the ground source heat pump system using energy piles already mentioned. Supplementary heating to cover peak loads will be taken from a connection to the district heating network that is intended for the site. The district heating connection will also be used as a back-up heat source and to generate domestic hot water.
The central equipment will be located in the basement and will circulate heating and cooling water up through each core of the building in distributed riser shafts. Distribution on the floors will be at high level in the ceiling void in gallery spaces and office areas. Heating and cooling water will also continue up to the roof to serve the building's air-handling units located there.
The building's cooling requirement is expected to be low as most of the year the external air temperature is below the target room temperature and the building's cooling demands are to be met by an all-air variable air volume ventilation system, which allows for free cooling (see the sustainability section above for further details). However, some cooling will still be required, particularly if Hungary continues to experience warmer summers in the long term and there is a desire to future-proof the building against climate change. This additional mechanical cooling will be provided

by the ground-source heat pump installation. In addition, the opportunity to use underground air labyrinths will be investigated for pre-cooling the fresh-air intake during the summer.

Galleries

Heat in the galleries will be delivered along the glazed perimeter areas where the main heat loss from the spaces will occur, and where there is a risk of discomfort from cold down-draughts. Heating pipework at high level will penetrate up through the slab to serve finned convectors at low level on the floor above. Distribution at high level will be carefully designed and routed to avoid any risk of water damage to artworks below.

Gallery cooling will be via the variable air volume ventilation system, described in the following section.

Offices

Heating and cooling in the offices will be distributed at high level in the ceiling void, but will serve active chilled beams at high level. The active chilled beams will provide heat during the winter period and cooling during the peak summer period. During shoulder seasons when conditions allow, natural ventilation can be used to cool the offices instead of the chilled beams, reducing the building's energy demands.

1.3.2 Ventilation

Most of the building will be predominantly mechanically ventilated with an option to naturally ventilate perimeter office and auxiliary spaces when external conditions are appropriate (see the sustainability section above for more details). Air-handling plant serving the gallery and office spaces will be located on the roof of the building, to minimise fresh air and exhaust ductwork runs. The units will be divided between the four cores so as to serve each corner of the building with its own dedicated equipment in accordance with the varying conditions experienced in each corner. Each quarter of the gallery space on each floor will be served by its own dedicated unit. Office spaces on all floors will be served by only one air-handling unit per quarter.

Air-handling units serving auxiliary spaces and the basement will be located in the basement, with fresh air taken though appropriate locations in the lower level façade, and exhaust air ducted to the roof. In all cases, fresh air and exhaust air points will be sufficiently separated to comply with BREEAM requirements.

Distribution of supply and extract ductwork will be in the ceiling void on all floors.

Galleries

The gallery spaces will be served by all-air mixing ventilation systems via variable air-volume boxes and supply air diffusers in the ceiling. The ventilation system will be designed to ensure consistent closely-controlled thermal conditions and strict acoustic requirements throughout the space.

Offices

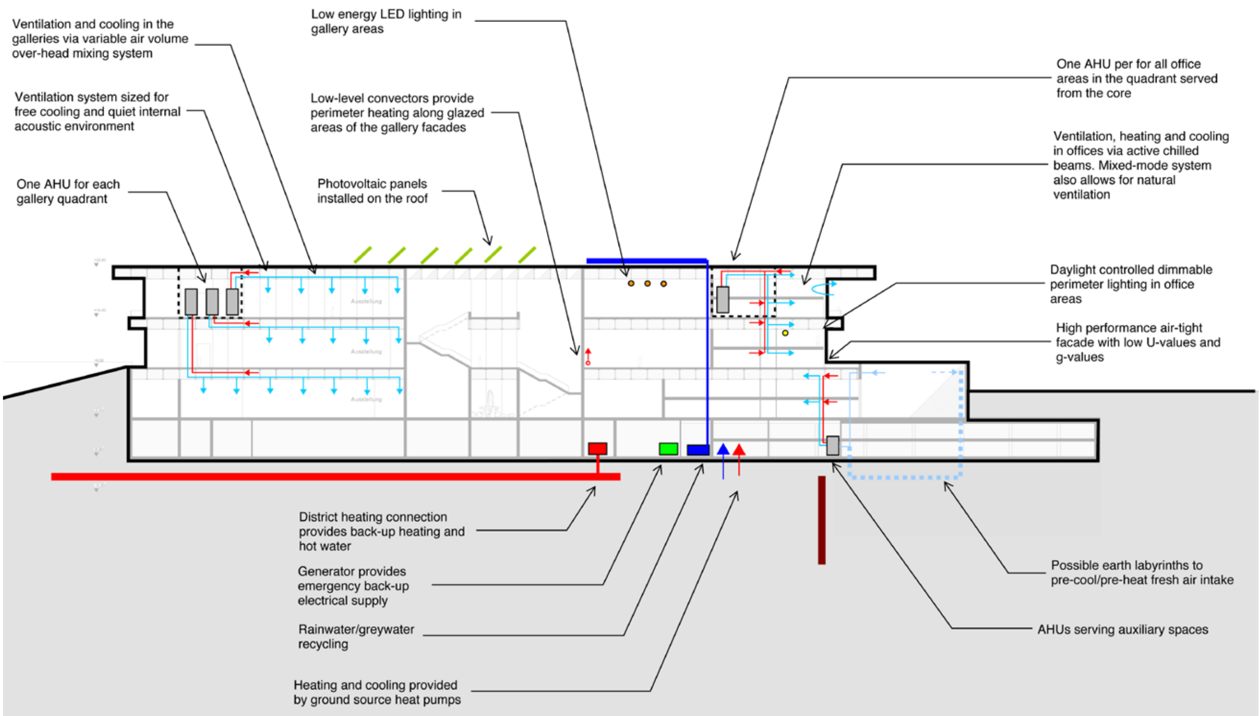
The offices and perimeter auxiliary areas will either be naturally ventilated through openable elements in the façade when external conditions are appropriate, or mechanically ventilated via the active chilled beams in the ceiling void during the rest of the year. Control systems will be explored at the design stage to help occupants know when to operate natural ventilation openings in the facade and to ensure that the mechanical systems are switched on and off accordingly.

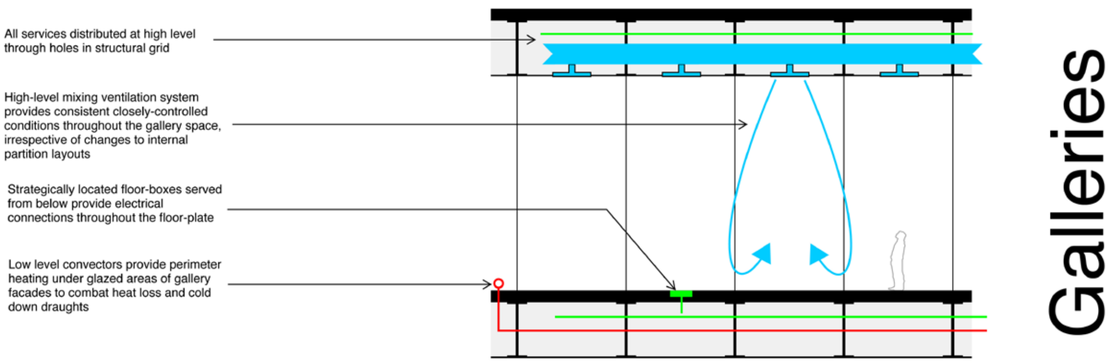
1.3.3 Electrical Systems

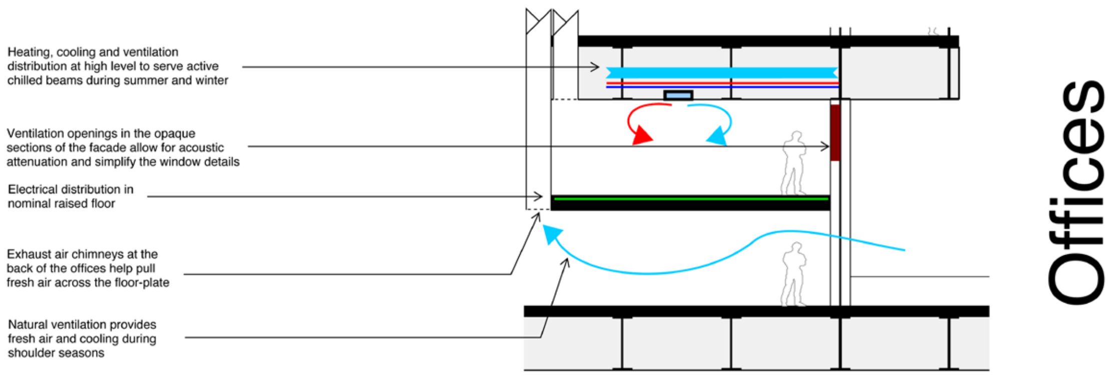
Electrical small power and IT cabling distribution will be at high level with penetrations through the slab into regularly distributed floor boxes serving the floor above. Lighting and fire systems cabling will also distribute at high level in the ceiling void. Central electrical rooms will be located in the basement adjacent to the car park and loading bay, to make servicing and replacement easier. Electrical distribution through the building will also be via distributed shafts in the four cores.
A generator is recommended to provide a back-up electrical supply for life-safety and art conservation systems.

1.3.4 Plumbing Systems

Domestic hot water will be generated from the building's district heating connection and distributed via riser shafts in the four cores.
Rainwater or grey water collection and recycling systems will be investigated for toilet and urinal flushing as well as façade cleaning and potentially irrigation, so as to reduce the potable water demand of the building. The central collection and distribution plant will be in the basement.
All sanitary fittings will be low-flow fittings so as to further reduce water demand.


Ventilation and cooling in the galleries via variable air volume over-head mixing system
Ventilation system sized for free cooling and quiet internal acoustic environment
One AHU for each gallery quadrant
Low energy LED lighting in gallery areas
Low-level convectors provide perimeter heating along glazed areas of the gallery facades
Photovoltaic panels installed on the roof
One AHU per for all office areas in the quadrant served from the core
Ventilation, heating and cooling in offices via active chilled beams. Mixed-mode system also allows for natural ventilation
Daylight controlled dimmable perimeter lighting in office areas
High performance air-tight facade with low U-values and g-values
District heating connection provides back-up heating and hot water
Generator provides emergency back-up electrical supply
Rainwater/greywater recycling
Heating and cooling provided by ground source heat pumps
Possible earth labyrinths to pre-cool/pre-heat fresh air intake
AHUs serving auxiliary spaces


All services distributed at high level through holes in structural grid
High-level mixing ventilation system provides consistent closely-controlled conditions throughout the gallery space, irrespective of changes to internal partition layouts
Strategically located floor-boxes served from below provide electrical connections throughout the floor-plate
Low level convectors provide perimeter heating under glazed areas of gallery facades to combat heat loss and cold down draughts
Galleries

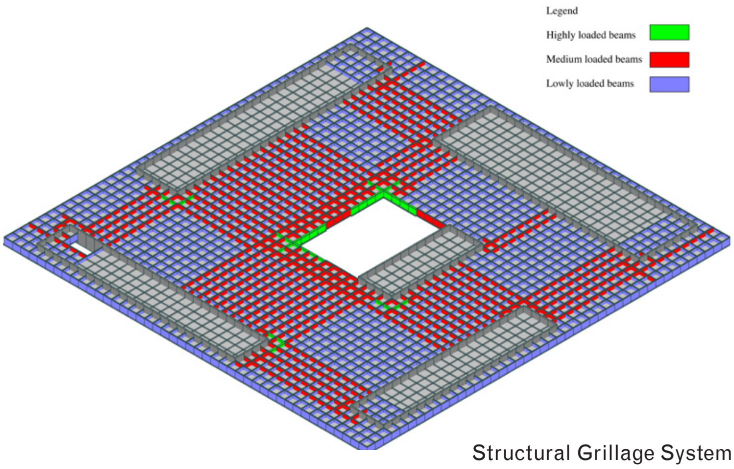

Heating, cooling and ventilation distribution at high level to serve active chilled beams during summer and winter
Ventilation openings in the opaque sections of the facade allow for acoustic attenuation and simplify the window details
Electrical distribution in nominal raised floor
Exhaust air chimneys at the back of the offices help pull fresh air across the floor-plate
Natural ventilation provides fresh air and cooling during shoulder seasons
Offices

2 Structures

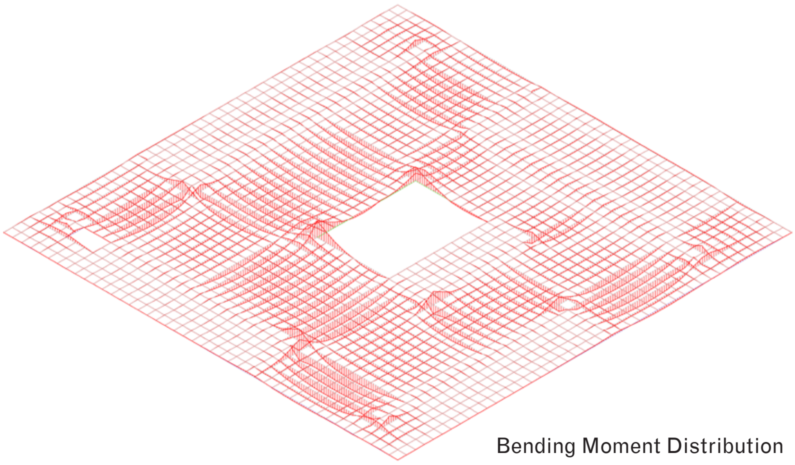
2.1 Building Description
The new Liget Museum building consists of three gallery exhibition levels above a single level basement floor housing primarily workshop and storage space. A strong feature of the museum spaces are large column free exhibition halls. Office and administration areas surround the exhibition spaces on the upper floors. The ground level of the building is constructed partly underground with access to the outside through a number of "pocket gardens" located around the around the building perimeter. Outside the main footprint of the building there is a 4-storey underground car park.

2.2 Building Stability System
The stability of this low rise building is provided by the ample presence of shear walls within the building located in the office blocks around the perimeter and the central core. The horizontal forces are transferred to the ground through the slab and retaining walls at the basement level.

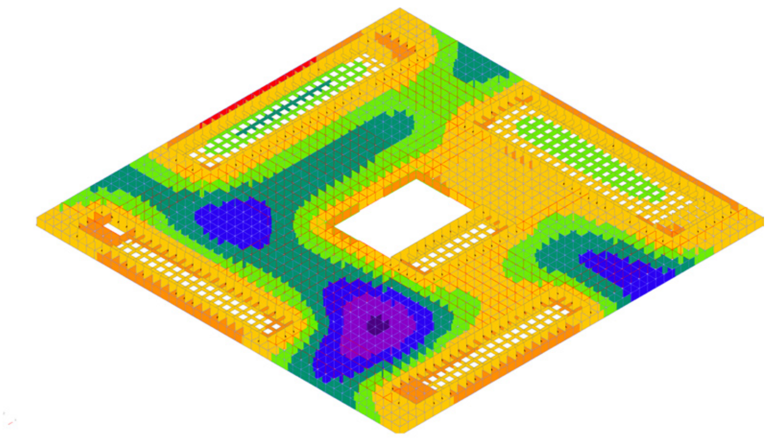
2.3 Superstructure Floor Structure
In order achieve the long clear spans required for the gallery spaces a composite steel and concrete grillage slab system has been selected. The slab structure consists of a thin concrete deck above steel plate girder beams spaced 2.7m apart arranged in two orthogonal directions.
The maximum clear span of the floor is approximately 30 meters between the central atrium and core structure to the office blocks located around the outer perimeter of the building. The regular grid of beams in both directions allows the floor to behave as a two-way spanning slab structure and is a structurally efficient and robust solution for the large spans achieved.
The depth of the all structural beams is maintained for the entire floor system in order to provide a consistent appearance and soffit level in the gallery spaces. The thickness of the plates used to form the plate girder beams is adjusted to match the stress levels in that particular location. This concept is similar to the way reinforcement levels are adjusted in a concrete flat slab structure and can be optimised further in later project stages.
The I-shaped plate girder beams allow the building service ducts to pass through openings in the web of the beams without affecting the performance of the structure.
The structural arrangement of the roof structure is similar to that of the floors below with lighter steel beams used due to the lighter loading requirements of the roof.
2.4 Basement Level and Car Park
The reduced span lengths in the basement structure and car parks enable the floor above this space to be constructed in reinforced concrete. The basement walls consist of earth retaining reinforced concrete walls with additional water proofing measures to protect the valuable art work in the storage rooms and exhibition spaces.
2.5 Pocket Gardens
The pocket gardens around the perimeter of the building are formed with a stiff reinforced concrete earth retaining structure which works in combination with the other basement walls.



Structural Grillage System



Bending Moment Distribution



3 Fire Safety Concept

The design of the building allows egress to outside on two levels, the basement and the ground floor level. This allows flexibility for the exhibition spaces at ground floor level as the stair cases exit at basement level.
The basement level and the ground floor level will separated into four fire compartments, using the partition walls between the different exhibition spaces. For normal operation the doors in these walls can be kept open. Each fire compartment can be evacuated by at least two stair cases.
Fire spread between the floors along the light well in the centre of the building will be prevented by protecting the glazing with a water spray system. The exhibition spaces will not be sprinklered.
The top floor is designed as one open space. It will be divided into four smoke compartment in the event of a fire. Each smoke compartment will be connected to at least two stair cases. To ensure a sufficient level of safety for occupants, fire brigade and exponents the escape route lengths are reasonable and a smoke ventilation management will keep smoke free layers within the smoke compartments. As this space is dedicated to the old paintings there will be only little fire load and hardly any ignition sources. In the event of a fire the mass burning rate is estimated to be very low.